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Quantifying Sediment Delivery History in Mediterranean Mountain Watersheds from Lake Records (Iberian Range, Spain)

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Land degradation and soil erosion are key environmental problems in Mediterranean mountains with long history of human occupation and strong seasonality of hydrological regimes. Monitoring studies in experimental catchments in the Pyrenees have identified main controlling factors on erosion dynamics but, because of the short time span, they do not integrate the diverse temporal and spatial variability of these environments. We propose a novel strategy based on multi-proxy analyses of lake sediments aimed to quantify sediment delivery and erosion dynamics. Karstic lakes in the Iberian Range (Spain) provide the opportunity to reconstruct the depositional evolution of Mediterranean mountain watersheds and to evaluate the response to both, anthropogenic and climate forcings during the last millennia.

Precipitation (rainfall intensity, seasonality, runoff production) and land cover (forest area, degraded areas, land uses) are key factors controlling erosion in both experimental and lake catchments. Values for Minimum Denuded Mass (Mdc) and Total Denudation Rate (DRt) measured in experimental catchments and reconstructed from lake sequences are comparable. In both settings, most sediment yield occurs during flooding events. The reconstructed sediment delivery to the lakes during flood events spans several orders of magnitude (less than 100 T to 98000 T) and the denudation rate ranges from 6 to 480 T km⁻² yr⁻¹. Reconstructed mass denudation values per event in the forested lake catchments are similar (less than 30 T km⁻² yr⁻¹) to sediment yields from a high altitude experimental watershed. Flood sediment yield values from an abandoned farmland experimental catchment (69 T km²) are in the lower range of lake watersheds (from 60 to 480 T km⁻² yr⁻¹). No lake watershed has reached the values documented for the badland catchment (3094 T km⁻²). These results underline the punctuated nature of sediment dynamics in Mediterranean landscapes at decadal and centennial scales.

Major periods of sediment accumulation in the lakes and denudation in the catchments during the last two millennia correspond with cooler and/or wetter climatic phases (Roman and Dark Ages, 0-800 CE and LIA 1200-1850 CE) and periods during the Middle Ages related to increased human pressure during the establishment of the highly complex system of sheep transhumance – the ‘Mesta’ Association - and consequent intense deforestation (12th-13th centuries). Recent changes associated to the rural exodus and land abandonment during mid-20th century are more clearly shown in larger watersheds as decreased sediment delivery due to recent afforestation.

Comparing the reconstructions from the Iberian lakes with data from experimental watersheds in the Pyrenees, the size of the watershed, the land cover and the erodibility of the geological formations and soils are key factors to control the sediment fluxes from mountains Mediterranean watersheds. The results highlight the critical effect of the catchment size related to the amount of sediments that reach the lakes and confirm the paramount role of vegetation cover and land use changes as main controls of erosion in Mediterranean watersheds at centennial scales.